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The compositions of 35 Roman bronze coins of the period A.D. 284–363

by LAWRENCE H. COPE* and HARRY N. BILLINGHAM*

The political and economic complexities of the Roman Empire in the late 3rd and early 4th centuries A.D. are manifest in the coinage of the period, which was issued in great variety in bronze and silver-surfaced bronze (and more rarely in the precious metals), from as many as fifteen different mints spread throughout the Empire and divided between different administrations for much of the time. It is now certain that the numerous coinage adjustments and reforms, and the frequent issues of new coin types, produced metallurgical problems at the mints in rapid succession, as the moneyers—faced also with increased outputs as inflation continued almost unabated—sought to meet the demands made upon them in the most practical way, yet within the limitations of monetary policies, most probably defined in edicts which have long since disappeared.

Since the metallurgical evidence of the coinage itself can be expected to reveal something of the metallurgical practices and attainments of the time, the variations in practice between different mints, and the manner in which the moneyers executed their official instructions, it can also be expected to reveal something of the intentions of the Emperors contained in missing coinage legislation. The common bronze coinage (much of which exists to this day) provides the most valuable information with the least loss to posterity, despite the inevitable destruction of the pieces for a comprehensive metallurgical examination. So, with the generous help of a number of museum directors, curators and keepers of coins, coins representative of some of the main issues of the period (the criterion being that they were clearly identifiable though of poor museum value) have been sought and sacrificed, with impunity, for their greater worth to advances in scientific numismatics.

Metallographic studies are still in progress, but since the 35 analyses completed in less than one year by one of us (H. N. Billingham) almost equals the total number of the less completely described, and often less accurate, analytical results published for coins of the same historical span within the last century of scientific enquiry, we consider that this substantial new contribution to the existing knowledge merits early publication together with some preliminary deductions.

All the chemical analyses have been made at the Wednesbury College of Technology by the kind permission of the Principal (Mr. H. A. MacColl) and the Head of the Department of Metallurgy (Dr. G. J. T. Hume), both of whom have given the authors every encouragement and facility for furthering a project which is already beginning to provide valuable information to scholars working in the field of Roman numismatics. Since the heterogeneities of structure of ancient coins introduce complications in the preparation of representative analytical samples, we have taken half-coin (or even whole coin) samples in the case of the smaller coins, and radial segments of the larger ones, after the mechanical removal (by abrasion or filing) of the remains of corrosion products, patination, or surface silvering. For analysis, the gravimetric wet-chemical methods recommended by Caley ('Analysis of Ancient Metals', Pergamon, 1964) have been used throughout.

Fairly complete analyses have been made for all the major alloying elements and most of the more probable impurities. In every case, copper—the basic material of all the coins—has been determined (by electrodeposition) and not obtained by difference. The analysis results, mostly on duplicate samples, are given in the Table with the coinage listed in chronological order of issue, so that the trends in composition as new issues were introduced and as the coin dimensions were changed, and the consequent developments in metallurgical alloying practices, can be seen to the best advantage.

INTERPRETATION OF THE RESULTS

(1) Lead content In general it is observed that the Roman aes coinage of the early 4th century A.D. consisted almost entirely of more-or-less leaded, and argentiferous, low- to medium-tin bronzes. The lead was often added liberally, in such quantity that in the majority of cases it is clearly evident in both analysis and microstructure as the principal alloying element. There is some correlation between the lead content and the coin dimensions, the tendency being for lead content to increase as the coin sizes were diminished and, presumably, as the rate of coin production had to be increased at the mints to satisfy official inflationary measures. No doubt the moneyers were aware that by increasing the lead content they could improve the castability of the coinage bronzes and, perhaps, also reduce the overall cost of the alloys, so that smaller cast buttons for the striking of the smallest coins could be prepared both more easily and cheaply. With the coins of the highest lead contents, the effects of segregation during solidification manifest themselves visibly in the macrostructure, and make it difficult to obtain either analytical totals near to 100% or duplicate analyses which agree as closely as those of the lower-leaded alloys in which the insoluble lead phase is more uniformly dispersed.

* Mr. L. H. Cope was a former student, and Mr. H. N. Billingham is now a Laboratory Technician, at the Wednesbury College of Technology, Wednesbury, Staffs.

(2) Tin content All the coins were found to contain between 1% and 6% of tin; the contents varied considerably between the products of different mints (particularly in the earlier part of the period), but the level seems always to have been maintained within the compositional range which results in the more malleable bronze alloys desirable for coining. The few microstructures examined so far (of the large folles of A.D. 294-306) reveal that these, the largest of the 4th century coins, were hot-struck from argentiferous bronzes that had been previously heated enough to remove all traces of delta-constituent and most of the cored dendritic remnants. The heat-treatment received was probably a consequence of the surface argentifising process which was clearly used for many (if not now visible on all) of these coins. Towards the end of the period studied (c. A.D. 360), there is some evidence of a trend towards the adoption of coinage bronzes of lower tin content. This economy in tin is particularly noticeable in those coins produced by the western mints of the Empire; whether the tin content was reduced in the coinage alloys at this time for metallurgical or economic reasons (or both) it is not yet possible to judge.

(3) Silver content An outstanding feature of many of the Roman Imperial coinage bronzes of the early 4th century is that they are found to contain various small amounts of silver within the coin alloys, apart from any superficial coating. The silver contents are observed to be at levels which are too high and too consistent in particular issues for them to be interpreted as being anything other than deliberate and controlled silver additions to the bronzes, undoubtedly to produce official standard coinage alloys of specified fineness. It is of considerable numismatic interest that the analyses establish that the earliest datable folles, with the GENIO POPVLI ROMANI reverse, all contain about 3.6% of silver in the bronze, whether they bear traces of surface silvering or not; this silver content is consistent despite considerable variations in the proportions of the lead and tin alloy components of the bronzes issued from different mints. The folles alloys appear to have been made, in the first instance, and for a longer period at the Eastern mints than in the West, to a standard of 10 scruples (20 obols) of silver per Roman pound of bronze. It is quite possible that the vexatious XXI mark, which some of the early folles of Eastern mintage bear, could refer to this silver investment, no doubt designed to engender public confidence in a token coinage which also bore some measureable and meaningful intrinsic value. The analyses of the later folles reveal a rapid series of debasements (particularly in the West), and then reductions in size and fineness which, together, effected a drastic reduction in the amount of silver invested in individual coins. This decline commenced less than a decade after the introduction of the Diocletianic follis. Later attempts at restoration need to be studies further in an attempt to establish what the changes in metallurgical practice and economic purpose really involved.

An interesting feature of a short-lived attempt at the restoration of a similar argentiferous bronze coinage (by the coinage reform of A.D. 348), is that it is now possible to discern different silver levels in coin types which have often been regarded as belonging to the same denomination. The genuine FEL TEMP REPARATIO 'Galley' coins clearly contain much more silver than another variety of the series, which is of identical size and weight (the 'Fallen Horseman' type). There is sufficient silver in the 'Galley' coin alloy, we believe, to have made its extraction a profitable pursuit to anyone with access to the pre-coined metal and a knowledge of a simple extraction process, say, by melting with lead and separating (by liquidation) the argentiferous lead for later cupellation. It is suspected, therefore, that the 'Galley' coin might be the pecunia maiorina to which an Edict of February A.D. 349 (in the Codex Theodosianus) refers, forbidding mint-workers to remove the silver from the pre-coined aes alloy, and making it a capital offence to do so.

We have also found a bronze coin which assays in the region of 1.4% silver, and which might be the original centenionalis. One of us (L. H. Cope) bases this thesis on the supposition that the name centenionalis—meaning, literally, 'containing 100 parts'—once really indicated that the coinage alloy used contained 100 wheat-grains of silver per Roman pound of bronze. An alloy identifiable with this composition is found to have been used for an early issue (No. 25; N.M.W.1) of the 'Fallen Horseman' variety of the FEL TEMP REPARATIO series; this issue coincides with the earliest known references to centenionales in the literature. We recognise the need for more analytical results to confirm and establish some of these preliminary deductions, and it is our intention to extend this work since it is becoming abundantly clear that a detailed study of the compositions of 4th century Roman Imperial bronze coinage (and of its silver content variations in particular) will reveal further information upon which the knowledge of official coinage policies, the relationships of the numerous denominations, and the mint practices of the time may be more firmly based and the precise nature of the coinage reforms more completely understood.

(4) Impurities in the coinage alloys

We have determined four common impurities: iron, nickel, cobalt and zinc. Usually there was insufficient sample to perform separate determinations of arsenic and antimony, and so emphasis was given to the acquisition (where possible) of two separate reliable analyses for each of the eight elements listed in the Table of analyses. In no case was zinc found present in alloying amounts, as is common in much earlier Roman aes coinage alloys, nor was there any indication of its use as a deoxidiser. Iron is found to be a common and variable contaminant, but it is usually present at levels which preclude the formation of a brittle secondary phase in the microstructure; it was not harmful, therefore, to the coining properties. The nickel and cobalt levels are of particular interest for indicating the sources of the coppers used as the bases for the alloys. It is well known that the higher nickel contents can indicate copper of Middle Eastern origin, but we have no explanation to offer at present for the high cobalt levels evident in some of the coin alloys which do not contain much nickel. Ultimately, we hope that it may become possible to trace copper sources more precisely, and to reveal if coinage alloys were prepared by the mints from the nearest or local materials, or whether they were supplied to the mints (for simple re-melting) by one or more centralized metal agencies. The contemporary forgers of ancient coins, if they had no access to official materials, might be expected to have used local supplies of metal and to have compounded their own alloys as nearly as they thought necessary to simulate the metallic colour and appearance of the regular issues. There is some evidence for this in the analysis of coin No. 26 (N.M.W. 15) which is possibly a good local copy of a coin minted at the Imperial mint of Antioch, using the most readily available copper of Middle Eastern origin.

Forgeries

It is characteristic of counterfeiters that they do not waste their efforts in forging coinage of little token value nor coinage of high intrinsic worth in the same alloys as the official issues. Our evidence reveals that in the 4th century counterfeiters preferred to copy the prototypes of argentiferous bronze of some intrinsic worth (and maybe of comparatively high token value) in alloys which were usually more highly loaded, and almost void of silver (see the 'Galley' forgeries Nos. 19-21 in the Table). Thus the over-tariffed and expensive to manufacture folles were rarely copied; yet there is, to this day, an abundance of copies of the 'Galley' and 'Fallen Horseman' issues of A.D. 348 and later, which could have been more readily fabricated in leaded (but silver-free) low-tin bronzes not very different from the argentiferous alloys of the official coinage of the period. It is probable that the forgers put a quantity of lead in their bronzes for the same metallurgical and economic reasons as the officials at the mints; but, being subject to no stricter metallurgical disciplines than those necessary for the unwitting acceptance by others of their products, they tended to use more lead. For further reasons of economy they would have seen no point in adding any silver to their counterfeit coin bronzes when the small amount of silver present in the official bronze coinage alloys could not be detected visually. Both these features become evident when the analyses of the counterfeit coins are compared with the genuine prototypes in the Table.

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Analyses of Thirty-Five Roman Bronze Coins of the Early Fourth Century A.D.

No.	Code No.	Emperor	Date of issue (A.D.)	Weight (grams)	Reverse type	Mint	CHEMICAL ANALYSIS - weight per cent: Copper	Tin	Silver	Lead	Iron	Nickel	Cobalt	Zinc	Total		Coin Reference
1	M. 3	Diocletian	284-294	3.07	CONCORDIA MILITVM (Antoninianus)	Antioch	92.23	3.94	1.12	0.74	0.50	0.17	0.63	0.09	99.42	1	
							92.43	3.79	1.19	0.87	0.37	0.13	0.55	0.06	99.39	2	R.I.C.
							92.33	3.87	1.16	0.81	0.44	0.15	0.59	0.08	99.43	Av.	306
2	Br. 14	Galerius	c. 295	9.28	GENIO POP/VLI ROMANI (Follis)	Siscia	90.69	3.35	3.22	2.84	0.02	0.03	0.01	0.01	100.17	1	R.I.C. VI
							90.32	3.36	3.03	2.75	0.03	0.02	0.01	0.02	99.54	2	
							90.51	3.36	3.13	2.80	0.03	0.03	0.01	0.02	99.89	Av.	Siscia 90 b.
3	Br. 16	Galerius	c. 300	9.07	GENIO POPV/L/I ROMANI (Follis)	Alexandria	91.05	2.20	3.35	3.39	0.02	0.03	0.20	0.01	100.25	1	R.I.C. VI
							91.01	2.24	3.36	3.27	0.02	0.04	0.18	0.01	100.13	2	Alexandria
							91.03	2.22	3.36	3.33	0.02	0.04	0.19	0.01	100.20	Av.	31 b.
4	M. 4	Diocletian	302-303	10.98	GENIO POPV/LI ROMANI (Follis)	Alexandria	90.63	2.38	3.55	3.14	0.03	0.07	0.08	0.10	99.98	1	R.I.C. VI
							Second Analysis sample accidentally spilled when in solution form									2	Alexandria
							90.63	2.38	3.55	3.14	0.03	0.07	0.08	0.10	99.98	Av.	34 a.
5	B. 54	Constantine I (as Caesar)	c. 305	8.43	GENIO POP/VLI ROMANI (Follis)	Lyons	87.02	4.38	1.71	6.30	0.33	0.04	0.21	0.05	100.04	1	probably
							87.16	4.45	1.69	6.43	0.37	0.06	0.20	0.06	100.42	2	R.I.C. VI
							87.09	4.42	1.70	6.37	0.35	0.05	0.21	0.06	100.25	Av.	Lyon 179 a.
6	B.M. 53	Maximian	307	6.43	GENI/O P ROM (Reduced Follis)	London	86.07	5.56	1.85	6.44	0.01	0.02	0.01	0.01	99.97	1	R.I.C. VI
							85.88	5.22	1.83	6.68	0.01	0.04	0.02	0.02	99.70	2	London 90
							85.98	5.39	1.84	6.56	0.01	0.03	0.02	0.02	99.85	Av.	
7	B.M. 56	Constantine I	315-316	3.97	SOLI INVI/CTO COMITI (Much-reduced follis)	Rome	80.55	4.97	0.82	12.76	0.07	0.07	0.05	0.03	99.32	1	R.I.C. VII
							80.05	5.12	0.83	13.34	0.10	0.09	0.04	0.01	99.58	2	Rome 40
							80.30	5.05	0.83	13.05	0.09	0.08	0.05	0.02	99.47	Av.	
8	B. 80	Constantine I	320-324	2.40	VOT. XX in wreath	Rome	88.96	4.79	1.87	4.51	0.03	0.02	0.01	0.01	100.20	1	Kent (N.C. 1957)
							88.11	4.48	1.83	4.95	0.04	0.04	0.01	0.01	99.47	2	No. 537
							88.54	4.64	1.85	4.73	0.04	0.03	0.01	0.01	99.85	Av.	
9	B.M. 59	Constantine II	322-323	3.49	BEAT TRANQLITAS VOT/IS/XX	London	95.20	0.21	1.83	1.71	0.41	0.02	0.06	0.01	99.45	1	R.I.C. VII
							95.65	0.41	1.85	2.00	0.43	0.03	0.03	0.01	100.41	2	London 259.
							95.43	0.31	1.84	1.86	0.42	0.03	0.05	0.01	99.95	Av.	
10	Y. 2	Constantine I	324-330	2.41	PROVIDEN/TIAE AVGG	Cyzicus	89.72	4.43	1.22	4.05	0.04	0.10	0.07	0.01	99.64	1	L.R.B.C. I
							89.50	4.28	1.40	4.05	0.05	0.10	0.08	0.01	99.47	2	1188
							89.61	4.36	1.31	4.05	0.05	0.10	0.08	0.01	99.57	Av.	
11	Ch. 14	(Urbs Roma)	330-335	2.14	Wolf and twins	Trier	87.14	2.42	0.94	9.35	0.62	0.03	0.08	Nil	100.58	1	as L.R.B.C. I
							86.72	2.40	1.01	8.95	0.71	0.07	0.11	Nil	99.97	2	70
							86.93	2.41	0.96	9.15	0.64	0.05	0.10	Nil	100.24	Av.	
12	W. 5	Constans	337-341	1.59	VIRTVS AVGG NN	Trier	76.72	3.20	Nil	19.34	0.04	0.05	0.03	0.02	99.40	1	L.R.B.C. I
							75.74	3.21	Nil	19.89	0.04	0.07	0.03	0.01	98.99	2	117
							76.23	3.21	Nil	19.62	0.04	0.06	0.03	0.02	99.21	Av.	
13	B.M. 26	Constans	341-347	1.16	VICTORIAE DD AVGGQNN	Trier	77.59	6.03	Nil	16.13	0.05	trace	0.02	Nil	99.82	1	possibly
							Insufficient sample for a duplicate analysis									2	L.R.B.C. I
							77.59	6.03	Nil	16.13	0.05	trace	0.02	Nil	99.82	Av.	116
14	W. 4	Constantine I	341-347	1.63	VN MR	Alexandria	80.05	2.95	0.44	16.22	0.08	0.10	0.07	0.01	99.92	1	L.R.B.C. I
							81.83	2.78	0.35	14.83	0.02	0.12	0.06	0.01	100.00	2	1473
							80.96	2.87	0.40	15.53	0.05	0.11	0.07	0.01	100.00	Av.	
15	W. 3	Constantine I	341-347	1.74	VN MR	Alexandria	78.09	4.26	0.26	17.36	0.02	0.02	0.02	0.02	100.05	1	L.R.B.C. I
							78.09	3.47	0.54	17.74	0.01	0.04	0.04	0.02	99.95	2	1477
							78.09	3.87	0.40	17.55	0.02	0.03	0.03	0.02	100.01	Av.	

No.	Code No.	Emperor	Date of issue (A.D.)	Weight (grams)	Reverse type	Mint	CHEMICAL ANALYSIS - weight per cent: Copper	Tin	Silver	Lead	Iron	Nickel	Cobalt	Zinc	Total		Coin Reference
16	Ch. 18	Constans	348-350	4.19	FEL TEMP REPARATIO	Alexandria	84.74	3.24	1.65	9.60	0.10	0.22	0.13	0.06	99.74	1	probably
					(Galley)		84.87	3.32	1.59	9.35	0.08	0.24	0.16	0.07	99.68	2	L.R.B.C. II
							84.81	3.28	1.62	9.48	0.09	0.23	0.15	0.07	99.73	Av.	2831 or 2835
17	B.M. 17	Constans	348-350	4.25	FEL TEMP/REPARATIO	Trier	83.14	2.55	2.20	11.41	0.10	0.06	0.21	0.02	99.69	1	L.R.B.C. II
					(Galley)		81.60	2.61	2.14	12.96	0.10	0.05	0.17	0.03	99.66	2	43
							82.37	2.58	2.17	12.19	0.10	0.06	0.19	0.03	99.69	Av.	
18	B.M.5	Constans	348-350	4.05	FEL TEMP/REPARATIO	Trier	78.43	2.40	2.35	16.55	0.22	0.03	0.04	0.008	100.03	1	L.R.B.C. II
					(Galley)		78.03	2.54	2.15	16.95	0.19	0.07	0.03	0.011	99.97	2	46
							78.23	2.47	2.25	16.75	0.21	0.05	0.04	0.010	100.01	Av.	
19	B.M. 6	Contemporary forgery Constantius II	348+	5.83	FELTEM/REPRARTIO	copy of Trier	73.74	1.65	0.36	23.45	0.20	0.03	0.09	0.04	99.56	1	
					(Galley)		74.84	1.91	0.36	22.51	0.02	0.04	0.07	0.03	99.78	2	—
							74.29	1.78	0.36	22.98	0.11	0.04	0.08	0.04	99.68	Av.	
20	B.M. 7	Contemporary forgery Constantius II	348 +	3.62	/PMSTIET	copy of Trier	85.71	2.48	0.43	10.65	0.06	0.06	0.19	0.05	99.63	1	
					(Galley)		85.09	2.48	0.42	11.16	0.07	0.05	0.10	0.07	99.44	2	—
							85.40	2.48	0.43	10.91	0.07	0.06	0.15	0.06	99.56	Av.	
21	W. 6	Contemporary forgery Constans	348 +	4.7	FEL TEM/PREPARATIO	copy of Lyons	73.05	1.91	0.36	24.64	0.02	0.04	0.12	0.01	100.15	1	copy of
					(Galley)		74.78	2.15	0.48	22.45	0.02	0.03	0.10	0.01	100.02	2	L.R.B.C. II
							73.92	2.03	0.42	23.55	0.02	0.04	0.11	0.01	100.10	Av.	185
22	B.M. 11	Constans	348-350	5.45	(Double struck) FEL TEMP. REPARATIO	Rome	87.68	2.32	1.10	7.89	0.12	0.08	0.14	0.04	99.37	1	as L.R.B.C. II
					(Hut)		87.90	2.17	1.09	8.17	0.09	0.09	0.14	0.06	99.71	2	604
							87.79	2.25	1.10	8.03	0.11	0.09	0.14	0.05	99.56	Av.	
23	B.M. 13	Constans	348-350	2.56	FEL TEMP REPA/RATIO	Rome	89.71	2.16	1.20	6.73	0.09	0.07	0.16	0.05	100.17	1	as L.R.B.C. II
					(Hut)		89.90	2.24	1.01	6.57	0.07	0.05	0.14	0.03	100.01	2	604
							89.91	2.20	1.11	6.65	0.08	0.06	0.15	0.04	100.10	Av.	
24	B.M. 21	Constantius II	348-350	2.34	FEL TEMP REPARATIO	Cyzicus	78.75	2.72	0.25	16.94	0.05	0.09	0.21	0.08	99.09	1	as L.R.B.C. II
					(Phoenix)		78.14	2.56	0.29	17.88	0.06	0.06	0.18	0.08	99.25	2	2483
							78.45	2.64	0.27	17.41	0.06	0.08	0.20	0.08	99.19	Av.	
25	N.M.W.1	Constantius II	348-350	4.69	FEL. TEMP RE/PARATIO	Aquileia	90.35	3.35	1.31	4.20	0.12	0.16	0.07	0.08	99.64	1	L.R.B.C. II
					(Fallen Horseman, 2)		90.58	2.87	1.47	4.12	0.14	0.14	0.08	0.08	99.48	2	893
							90.47	3.11	1.39	4.16	0.13	0.15	0.08	0.08	99.57	Av.	
26	N.M.W.15	Possibly a forgery Constantius II	348-350	4.19	FEL TEMP RE/PARATIO	Antioch	88.15	2.25	Nil	7.36	0.08	0.24	0.06	0.06	98.20*	1	possibly a copy of
					(Falling Horseman, 4)		88.11	2.24	Nil	7.50	0.08	0.22	0.08	0.07	98.30*	2	L.R.B.C. II 2620
							88.13	2.25	Nil	7.43	0.08	0.23	0.07	0.07	98.26*	Av.	
27	B. 85	Magnentius	351-353	6.08	SALVS DD NN AVG ET CAES	Uncertain	92.61	2.22	Nil	3.41	0.14	0.09	0.17	0.07	98.71*	1	L.R.B.C. II
					(Chi-Rho monogram)	(Gallic)	93.04	2.05	Nil	3.30	0.16	0.08	0.12	0.04	98.79*	2	19, 20, 22, 23
							92.83	2.14	Nil	3.36	0.15	0.09	0.15	0.06	98.78*	Av.	62, 236 or 445
28	B.M. 46	Constantius II	351-354	4.25	FEL TEMP RE/PARATIO	Heraclea	89.66	1.82	0.63	6.94	0.06	0.11	0.05	0.04	99.31	1	
					(Falling Horseman, 3)	Thracica	89.23	2.22	0.61	6.84	0.08	0.11	0.06	0.04	99.19	2	L.R.B.C. II
							89.45	2.02	0.62	6.89	0.07	0.11	0.06	0.04	99.26	Av.	1893
29	Y. 4	Gallus	351-354	2.15	FEL TEMP/REPARATIO	Thessalonica	83.58	1.78	Nil	12.93	0.48	0.22	0.14	0.07	99.20	1	possibly
					(Falling Horseman, 3)		83.20	1.74	Nil	13.22	0.50	0.24	0.12	0.04	99.06	2	L.R.B.C. II
							83.39	1.76	Nil	13.08	0.49	0.23	0.13	0.06	99.14	Av.	1682
30	B.M. 18	Constantius II	353-354	3.78	FEL TEMP RE/PARATIO	Amiens	91.63	1.26	0.22	6.97	0.07	0.07	0.05	0.03	100.30	1	
					(Falling Horseman, 3)		91.39	1.14	0.15	7.21	0.08	0.04	0.06	0.04	100.11	2	L.R.B.C. II
							91.51	1.20	0.19	7.09	0.08	0.06	0.06	0.04	100.23	Av.	25
31	B. 86	Constantius II	c. 355	1.99	FEL TEMP/REPARATIO	Uncertain	84.16	1.52	0.69	12.66	0.07	0.10	0.05	0.03	99.28	1	
					(Falling Horseman, 3)	(perhaps	83.92	1.40	0.50	12.90	0.05	0.10	0.02	0.01	98.90	2	uncertain
						Eastern)	84.04	1.46	0.60	12.78	0.06	0.10	0.04	0.02	99.10	Av.	
32	B. 89	Julian II	355-360	1.94	SPES REI/PVBLICE	Aquileia	68.87	3.15	Nil	24.35	0.20	0.04	0.14	0.08	96.83*	1	L.R.B.C. II
							72.04	4.25	Nil	19.28	0.25	0.02	0.08	0.04	95.96*	2	952, 954 or
							70.46	3.70	Nil	21.82	0.23	0.03	0.11	0.06	96.41*	Av.	956

No.	Code No.	Emperor	Date of issue (A.D.)	Weight (grams)	Reverse type	Mint	Copper	Tin	Silver	Lead	Iron	Nickel	Cobalt	Zinc	Total		Coin Reference
							CHEMICAL ANALYSIS - weight per cent										
33	B. 87	Constantius II	355-361	1.39	SPES REI/PVBLICE	Cyzicus	67.92	2.41	Nil	24.20	0.04	0.10	0.08	0.01	94.76*	1	possibly
							68.82	2.39	Nil	24.87	0.02	0.14	0.05	0.03	96.32*	2	L.R.B.C. II
							68.37	2.40	Nil	24.54	0.03	0.12	0.07	0.02	95.55*	Av.	2504 or 2506
34	B.M. 42	Julian II, Caesar	358-360	1.58	SPES REI/PVBLICE	Rome	63.01	0.57	Nil	35.06	0.01	0.04	0.15	0.06	98.90	1	L.R.B.C. II
							63.51	0.67	Nil	33.66	0.01	0.04	0.18	0.08	98.15	2	692
							63.26	0.62	Nil	34.36	0.01	0.04	0.17	0.07	98.53	Av.	
35	N.M.W. 22	Julian II, Augustus	361-363	7.18	SECVRITAS REIPVB (Bull and two stars)	Nicomedia	91.63	1.18	1.31	4.86	0.03	0.08	0.03	0.03	99.15	1	L.R.B.C. II
							91.85	1.20	1.34	4.93	0.03	0.10	0.01	0.01	99.47	2	2319
							91.74	1.19	1.33	4.90	0.03	0.09	0.02	0.02	99.32	Av.	

* Heavily corroded coins; low analysis totals due to internal corrosion penetration.